A STUDY ON STABILISATION OPTION FOR SOIL SUBGRADE IN LOW VOLUME BITUMINOUS PAVEMENTS

Thesis submitted in partial fulfillment of the requirements for the degree of

Bachelor of Technology
in
Civil Engineering
by

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CERTIFICATE

This is to certify that this thesis entitled "**A study on stabilization option for soil subgrade in low volume bituminous pavements**", put together by **Ms. Monalisha Chhotaray,** bearing the roll number **111CE0360**, a B. Tech scholar in the Civil Engineering Department, National Institute of Technology, Rourkela, in partial fulfilment for the award of the degree of **Bachelor of Technology** in **Civil Engineering**, is a bona fide record of a genuine research work completed by her under my guidance and supervision. This thesis has satisfied all the necessities according to the regulations of the institute and has, in my opinion, come to the standard required for submission. The results included in this thesis have not been uploaded/submitted to any other institute or university for any academic award, degree or diploma.

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ACKNOWLEDGEMENTS

My most recent four years venture at **National Institute of Technology, Rourkela** has added important and valuable experiences to my life. I have extreme regard and adoration for this institute and I will always remember the individuals who have made this environment so great and extraordinary. Now it is time to proceed onward to my future. Before I go, I would like to express my sincere gratitude to those who have assisted me along the way.

First and foremost, praise and sincere thanks goes to the Almighty for the blessing that has been bestowed upon me in all my endeavours.

I would like to express profound gratitude to my project supervisor, **Prof. Mahabir Panda** for furnishing me with a stage to chip away at an extremely energizing and testing field of **A study on stabilization option for soil subgrade in low volume bituminous pavements**. His untiring exertion, commitment and way of supervision is highly brain stimulating and extracts the best from a student. He has constantly given me the opportunity to envision, execute and analyse, but at the same time has the sharp guidance to keep me on track throughout the project work. This has helped me a lot for self-development for which I am obliged the most.

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Likewise, I want to convey my sincere thanks to all of my friends for their pleasant company and unending backing.

Most importantly, this would not have been possible without the affection and support of my Parents. My family has been a constant source of love, concern, support and strength all these years. I would like to express my heart-felt appreciation to them.

Monalisha Chhotaray

111CE0360

ABSTRACT

Life cycle cost analysis is a tool to determine total economic cost of a project segment by analysing initial cost and discounted maintenance cost. A productive maintenance work is the key for cost-beneficial and safe transportation. Yet, the maintenance work summed up from routine maintenance action per year to surface renewal and periodic renewal of the road network. KENPAVE is computer software, which helps in performing the response of pavement structure to traffic loading by computing stress and strain with in its layers and helps in the design of pavement. This study includes making a cost effective analysis and comparing that with two different design options to find out the best among them within the budget, before being done in field work. The objective of this project is to create a multi-objective pavement design model considering all necessary and sufficient factors responsible in maintenance activities of pavement so as to minimize the total cost. In this study, fly ash has been used for soil stabilisation of sub grade to facilitate the benefits of the stabilisation and to analyse the total cost of the project.

Keywords: *Life cycle cost analysis; KENPAVE, pavement design model, fly ash.*

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ABBREVIATIONS

CBR	-	California Bearing Ratio
cc	-	Cubic Centimetre
CL	-	Clay with Low Liquid Limit
cm	-	Centimetre
cum	-	Cubic Metres
ESAL	-	Equivalent Single Axle Load
gm	-	Gram
GSB	-	Granular Sub-Base
HMP	-	Hot Mix Plant
Kg	-	Kilogram
KL	-	Kilo Litres
Km	-	Kilometre
kN	-	Kilo Newton
KPa	-	Kilo Pascal
LCCA	-	Life Cycle Cost Analysis
m	-	Metre
mm	-	Millimetre
MoSRT&H	-	Ministry of State Road Transport & Highways
MPa	-	Mega Pascal
NPV	-	Net Present Value
OMC	-	Optimum Moisture Content
PMGSY	-	Pradhan Mantri Gram Sadak Yojana
PRR	-	Pneumatic Road Roller

PV	-	Present Value
sqm	-	Square Metres
T & P	-	Tools & Plant
TPH	-	Tonnes Per Hour
TxDOT	-	Texas Department of Transportation
VG	-	Viscosity Grade
WBM	-	Water Bound Macadam
γd	-	Maximum Dry Density

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The design of a pavement is mostly dependent on the subgrade soil characteristics representing the strength behaviour. In general, the soil subgrade, mostly granular in nature has better strength compared to that with fine grained soil. Keeping this in mind it is obvious that the clayey subgrade would require higher thicknesses of pavement layers. In many places, the locally available soil might be of this category and procurement of quality soil for subgrade purpose may not only be difficult, but also might involve huge costs. With advent of technology and specifications, the local poor soil may be improved to cater to the better subgrade soil strength requirements. One important and popular method is use of stabilisation technique. However, while sufficient strength is achieved due to this, the process also involves cost. Hence it is imperative to ascertain or establish the options involved in stabilisation process. One of the important method to decide a design and execution option is to apply the lifecycle cost analysis approach, in which the overall cost and overall life of each design option is arrived. The design option with least life cycle cost per year is finally decided for adoption. This study presents a review of life cycle cost analysis technique in general and apply the same to a situation when, the poor soil subgrade may be stabilised in a particular manner to establish the need for the same before execution. A simple example of a low volume bituminous pavement has been considered as a matter of sample study.

1.2 LIFE CYCLE COST ANALYSIS

Life cycle cost analysis (LCCA) is a methodology for assessing the total construction cost of a road project by examining initial cost including user cost and discounted future costs, for example, maintenance, rehabilitation, restoration, and salvage cost, over the design life of the project segment.

Bituminous pavement design is a process where definite designing and economic considerations are given to combinations of sub base, base, and bituminous surface material which will give satisfactory load bearing capacity. Variables that are considered include: materials, layer thickness, traffic, atmosphere, upkeep and seepage and life cycle costs. LCLA involves following three parameters as reported by Walls III et al. (1998).

1.2.1 Initial Cost

It is generally the initial construction cost of the structure where incentive/disincentive instalments ought not to be incorporated since they would reflect user advantages or expenses before structure going into carried out. This is the cost of development of the pavement which fundamentally relies on the pavement thickness, calculated by the sub grade strength of the soil and CBR value which depends upon the traffic category, cost of materials, machinery and labour.

1.2.2 Rehabilitation/Maintenance Cost

The maintenance/rehabilitation cost includes the preservation of pavement during the design life period of pavement to upkeep the structure. In event of low volume roads like that under Pradhan Mantri Gram Sadak Yojana(PMGSY), upkeep of these structures is to be carried out by the particular state government from its accessible budgets which incorporates routine maintenance every year, surface renewal and periodic renewal.

1.2.3 Analysis Period:

Time needed for the analysis of the bituminous pavement design which is taking into account a probabilistic model of 25 years for pavements. This is the time period over which beginning and future expenses connected with alternative pavement methods are assessed. This period may also vary depending on specific programmes and executing agencies.

Figure 1.1 below represents a typical expenditure calculation in a pavement construction during the design life period.

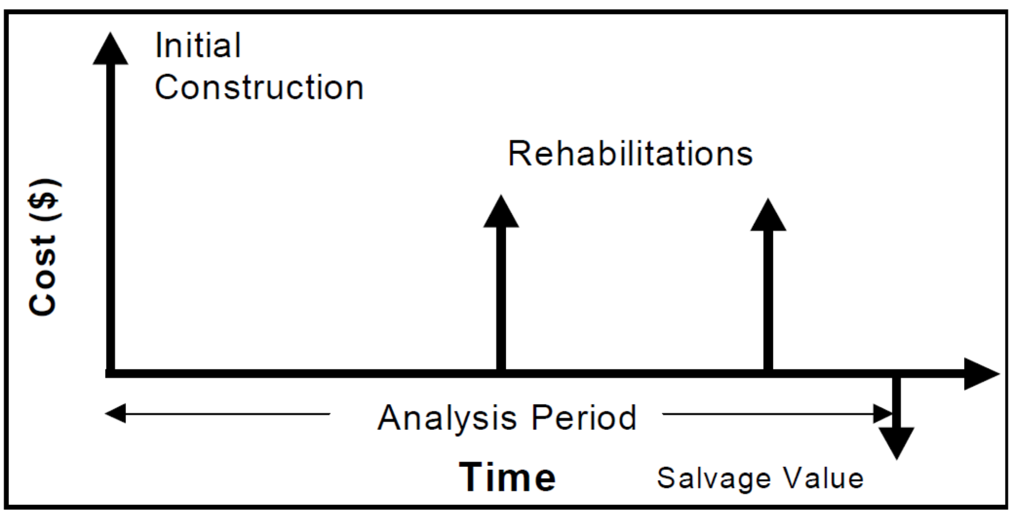

Figure1.1 Typical expenditure stream diagram for a pavement design alternative
(Walls III et al., 1998)

1.3 OBJECTIVES AND SCOPE OF WORK

The main objective of this study is to compare design options of a conventional bituminous pavement for low volume road passing through a clayey subgrade with low CBR value in contrast with the same road with stabilisation technique applied to achieve higher strength of soil subgrade for the same road. It is intended to apply a tool for life cycle cost analysis (LCCA) for the decision of the design option for these two situations. In order to achieve this, the following scope of work is proposed. It is expected that this procedure would give engineers and highway administration with a reasonable and cost-beneficial strategy to evaluate alternative pavement types with overall low construction cost.

1. As low volume roads involve vertical subgrade strain as the main criteria for design, the same is to be detrmined with established Kenpave software.
2. To identify the initial investment cost for bituminous pavements of low volume roads.
3. To identify the types of maintenance for bituminous pavement of low volume roads.
4. To find out life cycle cost analysis of pavement alternatives.
5. To carry out economic comparison of bituminous pavements for design life and to assess the most economical pavement design option.

CHAPTER 2

LITERATURE REVIEW

In general pavements detriorate with time. In particular, bituminous pavements require timely maintenance/ rehabilitation in order to maintain the desired level of serviceability. Walls III et al. (1998) reported the variation of pavement condition with respect to analysis period or pavement life as depicted in Figs. 2.1 and 2.2 respectively, taking into consideration different types of maintenance/ rehabilitation alternatives.

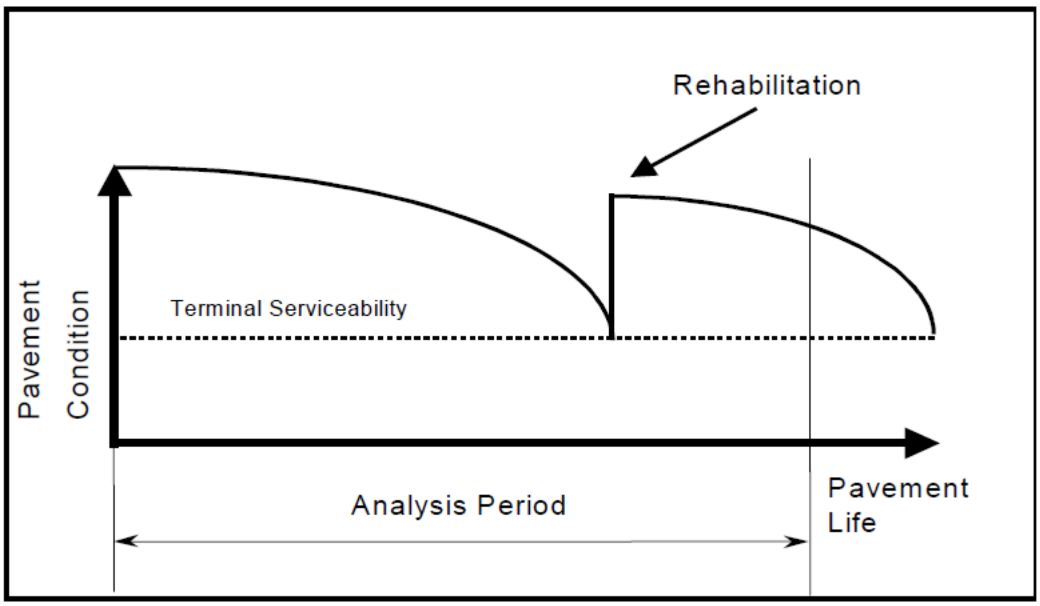

Figure 2.1 Analysis period for a pavement design alternative (Walls III et al., 1998)

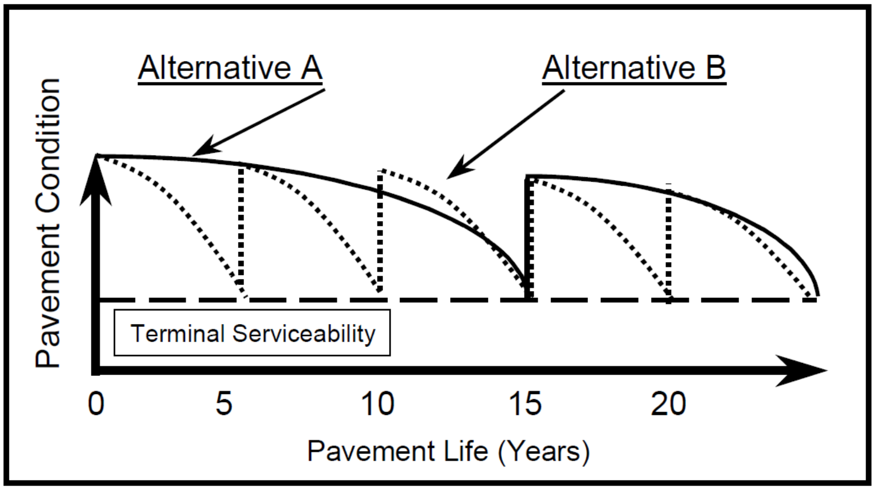

Figure 2.2 Performance curve versus rehabilitation strategy (Walls III et al., 1998)

Walls III et al. (1998) prescribed methods for leading Life-Cycle Cost Analysis (LCCA) of pavements, gives detailed methods to focus work zone user costs, and acquaints a probabilistic methodology with record for the uncertainty connected with LCCA inputs. It examines the variability and inalienable instability associated with input parameters, and gives suggestion on worthy ranges to the estimation of time and discount rates. They also showed that discount rates as an economic indicator can essentially impact the pavement analysis result. LCCA ought to utilize a logical discount rate that reflects authentic patterns over long time period. Information on the recorded trends over long time demonstrate that the constant estimation of cost followed discount rate nearly 4 percent. As per them Net Present Value (NPV) is the economic efficiency index of analysis to determine LCCA used to assess the long term economic proficiency between different pavement alternatives. When all costs and their timing have been produced, future costs must be marked down to the base year and added to the initial construction cost to focus on the NPV for the LCCA alternative. And the essential NPV formula for discounting maintenance costs in each year is:

$$NPV = \text{initial cost} + \sum_{K=1}^{N} \text{Rehab cost}_{\text{k}} \left[\frac{1}{(1+i)^n} \right]$$

Where, i = discount rate

n = design life period

$\left[\frac{1}{(1+i)^n} \right]$ = Present value (PV) factor

Fabrycky et al. (1991) proved that LCCA considers initial construction cost, future costs, and the time-estimation of money to calculate in the estimations. That is the reason future costs ought to be discounted to present value particularly if the life of the structure is long. They recognized the stochastic way of LCCA estimation which recommends a sensitive examination to get along with the uncertainty.

The primary objective of Wimsatt et al. (2007)'s research was to give TxDOT with guidelines to pavement alternatives considering rigid versus flexible pavement designs with permitted alteration, including a practical model for choosing whether or not to choose pavement structure alternatives for substitution. By utilizing the rules for alternatives, TxDOT ought to get the best cost for a project. Alternate options ought to draw in more contractors, expanding competitiveness among them with the point of bringing about lower construction costs.

Prabhat et al. (2009) found that the initial construction cost of pavement relies on the aggregate cost; cost of binder material, vehicle operating charges and cost of labour work and so on. The rehabilitation cost of road relies on various elements among them are the volume and traffic intensity, cost of materials, machines and labour, kind of area, sort of wearing surface, the lower level of serviceability which is satisfactory for that road category, climatic conditions etc.

Johnson (2008) examined about current issues confronting road problems. They discussed about new methods for soil stabilisation of gravel roads, recovery process for full depth of the roads and gave data about how to stabilise the soil. They additionally stated cost-security enhancements, best practices and assets in pavement design methods for roads.

Jain et al. (2004) discussed that the adaptable maintenance procedures after an analysis period of twenty five years can very well save more than thirty three percent roadway organization cost than that of planned maintenance cost. As the budget allowed for maintenance of the structure is just 60 percent of the fund granted, they arranged an advanced and organized work process for 60 percent plan accessibility.

Prabhakar et al. (2003) observed that the response of a bituminous pavement structure to traffic loading is mechanically demonstrated by calculating stresses and strains in its layers. Pavement stress-strain examination is a perfect instrument for systematic displaying of pavement behaviour and accordingly, constitutes an indispensable part of pavement design and helps in performing the analysis.

Pradhan Mantri Gram Sadak Yojana (2006) exhibited the decision of the proper cost beneficial and better alternative of pavement design was made via doing life cycle cost analysis, which takes into record the initial construction cost and rehabilitation cost. They additionally exhibited the cost of development for both rigid and flexible pavements and analysed that the life cycle cost of rigid pavement is around twenty to twenty five percent lower than bituminous pavement.

Walubita et al. (2000) stated the behaviour of soils in mix with fly ash to enhance the load bearing capacity of the soil using percentage from 9 to 46% by weight of soil for three different types of soils. The fundamental conclusion of this study is to survey the helpfulness of fly ash, a soil admixture for stabilisation and to enhance the rheological soil properties. The present study covers the characteristics of soil and fly ash, compaction curve, settlement, California bearing ratio, shear strength parameters etc.

CHAPTER 3

3.1 PROBLEM STATEMENT

The motive of this study was to compare and develop a decision strategy for design options for a low volume road under certain assumed conditions. In this work the above objective is to be achieved by formulating a multi-objective optimization model considering KENPAVE software analysis, considering all necessary factors responsible for this. The material and rainfall have been taken as under average condition. The whole work comprises to make an effective pavement model to minimize total construction cost and increase the total return subject to all the practical limitations.

3.2 LCCA FOR A ROAD UNDER PMGSY

The following guidelines/assumptions for the design of flexible/bituminous pavements for low volume rural roads according to IRC SP:72-2007:

For the pavement design data needed;

i) Annual daily traffic = 800

ii) Traffic growth rate per annum = 6 % if adequate data are not provided

iii) Design life = 10 years

iv) Design CBR of sub grade soil = 3.5 %

3.3 DESIGN CALCULATION

1. Taking Cumulative ESAL applications over 10 years @ 6% growth rate = 3,05,000
2. Total pavement minimum thickness for CBR 3.5 % and traffic greater than 1,00,000

   ESAL = 450 mm
3. Pavement composition from pavement design catalogues, CBR 3.5%

a) Bituminous Surface treated WBM = 75 mm
b) Road base = 150 mm WBM
c) Granular Sub-base = 250 mm including improved sub grade

3.4 KENPAVE ANALYSIS

KENPAVE software is generally used to find the response of a pavement structure to traffic loading which can be further modelled by computing stresses and strains within its layers. It also helps in performing the total cost calculation of different alternatives for pavement design.

Figure 3.1 KENPAVE Software Main Screen

3.4.1 Input

Relation between CBR and E according to IRC 37-2012

a) Sub grade : E1(MPa) = 10*CBR if CBR<5%

= $17.6*CBR^{0.64}$ if CBR > 5%

b) Granular sub base and base: E2(MPa) = $E1*0.2*h^{0.45}$

2. Poisson's ratio for pavement layers

   a) Sub grade = 0.50

   b) Sub base = 0.35

   c) Base = 0.35

   d) Bituminous layer = 0.30

3. Contact pressure = 700 KPa

4. Contact radius = 13.5 cm (80 kN: standard axle load with dual tyres)

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Length and displacement in cm, stress and modulus in kPa
unit weight in kN/m^3, and temperature in C

THICKNESSES OF LAYERS (TH) ARE : 22.5  10
POISSON'S RATIOS OF LAYERS (PR) ARE : 0.35  0.35  0.35
VERTICAL COORDINATES OF POINTS (ZC) ARE:  0  47.5
ALL INTERFACES ARE FULLY BONDED

FOR PERIOD NO. 1 LAYER NO. AND MODULUS ARE :    1  1.121E+05   2  1.121E+05
   3  1.121E+05

LOAD GROUP NO. 1 HAS 1 CONTACT AREA
CONTACT RADIUS (CR)--------------- =  13.5
CONTACT PRESSURE (CP)------------- =  700
RADIAL COORDINATES OF  1  POINT(S) (RC) ARE :  0

PERIOD NO.  1   LOAD GROUP NO.  1

  RADIAL     VERTICAL     VERTICAL    VERTICAL    RADIAL   TANGENTIAL    SHEAR
COORDINATE  COORDINATE  DISPLACEMENT   STRESS     STRESS     STRESS     STRESS
                                      (STRAIN)   (STRAIN)   (STRAIN)   (STRAIN)
  0.00000     0.00000     0.16159     700.000    834.641    834.641     0.000
 (STRAIN)                            3.548E-03  1.774E-03  1.774E-03  .000E+00
  0.00000    47.50000     0.03587      76.990     -2.496     -2.496     0.000
 (STRAIN)                            7.024E-04 -2.548E-04 -2.548E-04  .000E+00
```

Figure 3.2 Relation between critical parameter (vertical strain) and cumulative ESAL applications for CBR 3.5%

3.5 EFFECT OF SOIL-STABILISATION

Soil stabilization is a strategy went for expanding or maintaining the stability of the soil mass and compound modification of soils to improve their designing properties. Advantages of the stabilization methodology can incorporate higher resistance values, decrease in plasticity, lower permeability, depletion in pavement thickness, disposal of removal material pulling or handling. (Prabhakar, et al., 2003)

Table 3.1 Engineering properties of soils used in the study Prabhakar et al. (2003)

S. No	Soil Properties	Values [Soil]
1	**Specific gravity**	2.3
2	**Grain size analysis (%)**	
	Gravel	1.55
	Sand	2
	Silt	67
	Clay	29.45
3	**Consistency limit**	
	Liquid limit (%)	29
	Plastic limit	15
	Plastic index	14
4	**Texture of classification based on**	
	Plasticity chart	CL
5	**Compaction study**	
	Optimum moisture content (OMC), %	14.57
	Maximum dry density (gm/cc)	1.71
6	**Shear parameters**	
	Cohesion (Kg/cm2)	0.25
	Angle of shearing resistance	$30^{o}15'$

Table 3.2 Engineering properties of fly ash used in the study
Prabhakar et al. (2003)

S. No	Soil Properties	Values
1	**Specific gravity**	1.73
2	**Grain size analysis(%)**	
	Gravel	-
	Sand	69
	Silt	25
	Clay	6
3	**Compaction study**	
	Optimum moisture content (OMC), %	44.24
	Maximum dry density (gm/cc)	0.94
4	**Shear parameters**	
	Cohesion (Kg/cm2)	0.15
	Angle of shearing resistance	$29^o21'$

Table 3.3 Effect of soils mixed with different concentration of fly ash on OMC
Prabhakar et al. (2003)

Sl. No.	% Fly ash	γd [Soil]
1	0	1.71
2	9	1.58
3	20	1.57
4	28.5	1.44
5	35.5	1.39
6	41.2	1.36
7	46	1.34
8	100	0.94

Here 46% fly ash are used for soil stabilization of sub grade which increase the CBR to 11.6% with γd = 1.34 gm/cc.

For different traffic intensity and CBR 11.6% analysis goes like:

Table 3.4 Cumulative ESAL applications v/s pavement layer thickness according to pave design catalogue based on SP 72-2007

Sl. No.	Cumulative ESAL applications	Pavement layers thickness (mm)	
		WBM	GSB
1	200000-300000	175	100
2	300000-600000	175	125
3	600000-1000000	225	125

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SYSTEM OF UNITS (NUNIT)------------=  1

Length and displacement in cm, stress and modulus in kPa
unit weight in kN/m^3, and temperature in C

THICKNESSES OF LAYERS (TH) ARE : 17.5
POISSON'S RATIOS OF LAYERS (PR) ARE : 0.35  0.35
VERTICAL COORDINATES OF POINTS (ZC) ARE:  0  27.5
ALL INTERFACES ARE FULLY BONDED

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CONTACT PRESSURE (CP)------------- =  700
RADIAL COORDINATES OF  1  POINT(S) (RC) ARE :  0

PERIOD NO.  1   LOAD GROUP NO.  1

   RADIAL      VERTICAL     VERTICAL     VERTICAL    RADIAL   TANGENTIAL   SHEAR
 COORDINATE   COORDINATE  DISPLACEMENT   STRESS      STRESS     STRESS     STRESS
                                        (STRAIN)    (STRAIN)   (STRAIN)   (STRAIN)
   0.00000      0.00000      0.07831    700.000     595.000    595.000     0.000
  (STRAIN)                             1.340E-03   6.699E-04  6.699E-04  .000E+00
   0.00000     27.50000      0.03077    193.657      -0.124     -0.124     0.000
  (STRAIN)                             9.156E-04 -3.207E-04 -3.207E-04  .000E+00
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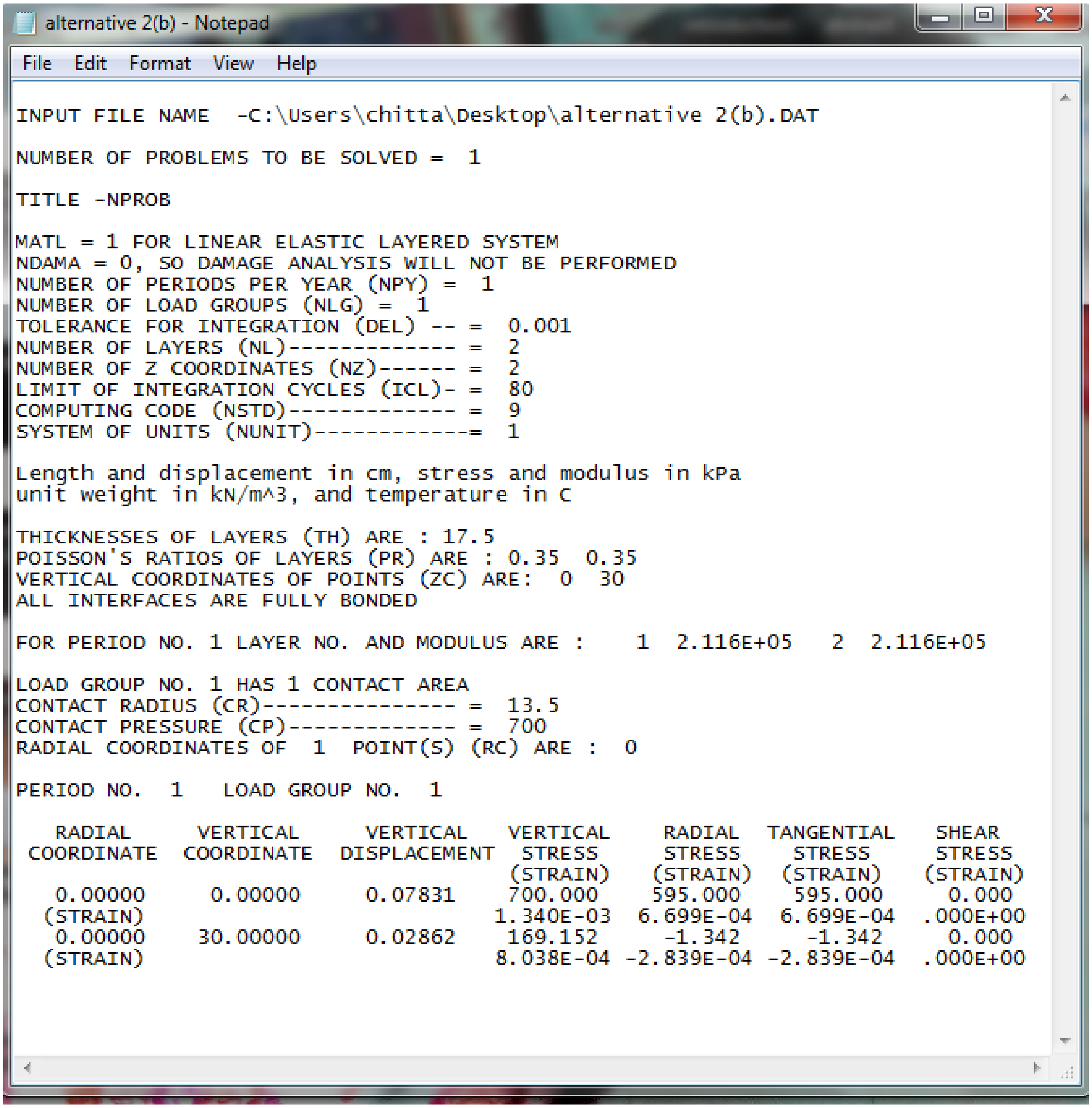
Figure 3.3 Determination of vertical strain for cumulative ESAL applications 2,00,000 – 3,00,000



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NUMBER OF LAYERS (NL)------------- =  2
NUMBER OF Z COORDINATES (NZ)------ =  2
LIMIT OF INTEGRATION CYCLES (ICL)- =  80
COMPUTING CODE (NSTD)------------- =  9
SYSTEM OF UNITS (NUNIT)------------=  1

Length and displacement in cm, stress and modulus in kPa
unit weight in kN/m^3, and temperature in C

THICKNESSES OF LAYERS (TH) ARE : 17.5
POISSON'S RATIOS OF LAYERS (PR) ARE : 0.35  0.35
VERTICAL COORDINATES OF POINTS (ZC) ARE:   0  30
ALL INTERFACES ARE FULLY BONDED

FOR PERIOD NO. 1 LAYER NO. AND MODULUS ARE :    1  2.116E+05   2  2.116E+05

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 COORDINATE   COORDINATE  DISPLACEMENT   STRESS     STRESS     STRESS     STRESS
                                        (STRAIN)   (STRAIN)   (STRAIN)   (STRAIN)
   0.00000      0.00000      0.07831    700.000    595.000    595.000     0.000
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  (STRAIN)                             8.038E-04 -2.839E-04 -2.839E-04  .000E+00
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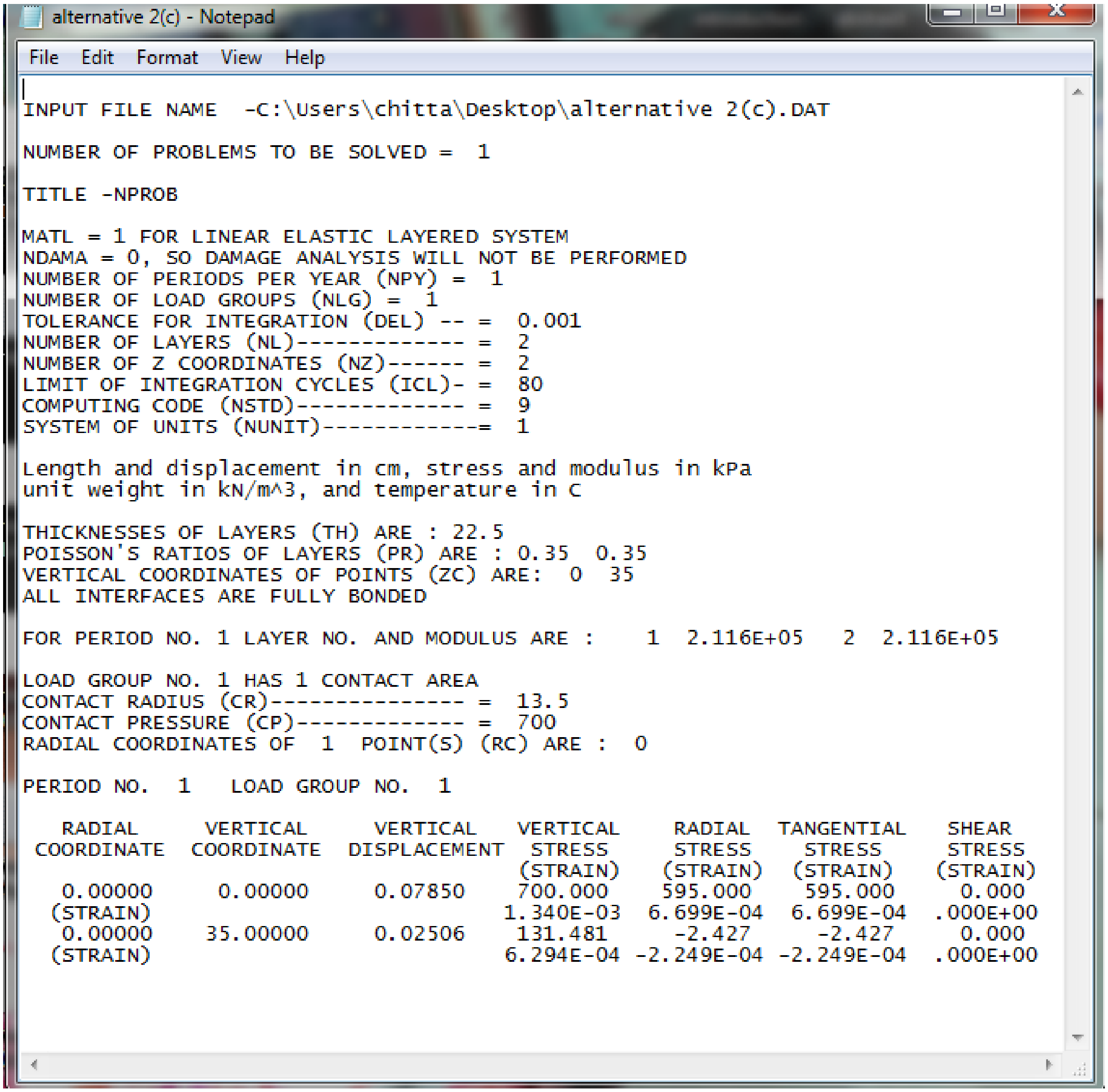
Figure 3.4 Determination of vertical strain for cumulative ESAL applications 3,00,000 – 6,00,000



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NUMBER OF LOAD GROUPS (NLG) =  1
TOLERANCE FOR INTEGRATION (DEL) -- =  0.001
NUMBER OF LAYERS (NL)------------- =  2
NUMBER OF Z COORDINATES (NZ)------ =  2
LIMIT OF INTEGRATION CYCLES (ICL)- =  80
COMPUTING CODE (NSTD)------------- =  9
SYSTEM OF UNITS (NUNIT)------------=  1

Length and displacement in cm, stress and modulus in kPa
unit weight in kN/m^3, and temperature in C

THICKNESSES OF LAYERS (TH) ARE : 22.5
POISSON'S RATIOS OF LAYERS (PR) ARE : 0.35  0.35
VERTICAL COORDINATES OF POINTS (ZC) ARE:  0  35
ALL INTERFACES ARE FULLY BONDED

FOR PERIOD NO. 1 LAYER NO. AND MODULUS ARE :    1  2.116E+05   2  2.116E+05

LOAD GROUP NO. 1 HAS 1 CONTACT AREA
CONTACT RADIUS (CR)--------------- =  13.5
CONTACT PRESSURE (CP)------------- =  700
RADIAL COORDINATES OF  1  POINT(S) (RC) ARE :  0

PERIOD NO.  1   LOAD GROUP NO.  1

   RADIAL      VERTICAL     VERTICAL     VERTICAL    RADIAL   TANGENTIAL   SHEAR
 COORDINATE   COORDINATE  DISPLACEMENT    STRESS     STRESS     STRESS     STRESS
                                         (STRAIN)   (STRAIN)   (STRAIN)   (STRAIN)
   0.00000      0.00000      0.07850     700.000    595.000    595.000     0.000
  (STRAIN)                              1.340E-03  6.699E-04  6.699E-04  .000E+00
   0.00000     35.00000      0.02506     131.481     -2.427     -2.427     0.000
  (STRAIN)                              6.294E-04 -2.249E-04 -2.249E-04  .000E+00
```

Figure 3.5 Determination of vertical strain for cumulative ESAL applications 6,00,000 – 10,00,000

3.5.1 Critical parameter analysis for different traffic

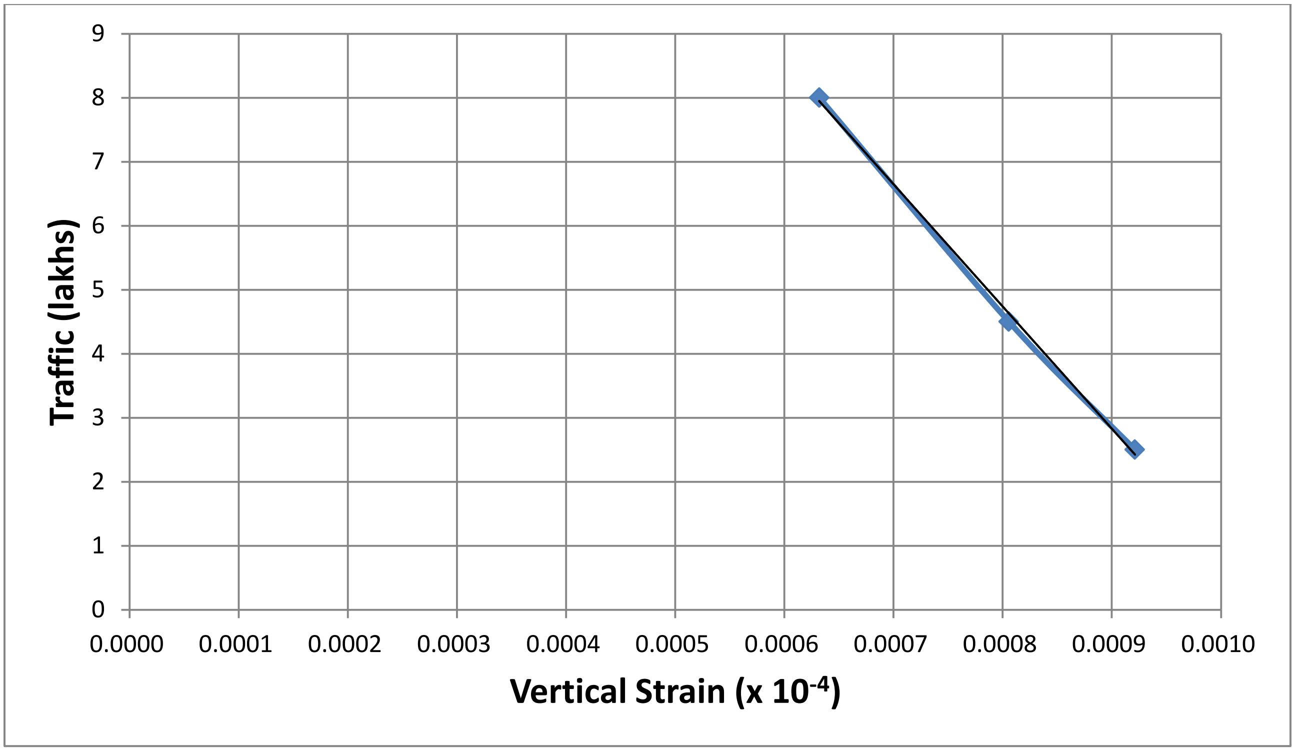

Figure 3.6 Relationship between vertical strain and traffic for CBR 11.6%

For x = 0.0007024, by trend line equation the value of y = 6.689813 lakhs (Traffic).

3.6 DATA RESULTED FROM KENPAVE ANALYSIS AND DESIGN CATALOGUE

1) Pavement composition from pavement design catalogues, CBR 11.6% and traffic=6.6898 lakhs

a) Bituminous Surface treated WBM = 75 mm
b) Road base = 150 mm WBM
c) Granular Sub-base = 125 mm

2) According to SP 72-2007 for traffic 6.6898 lakhs and a growth rate of 6% design life = 17 years

3.7 COMPARISON OF TWO DESIGN ALTERNATIVES WITH RESPECT TO SAME CRITICAL PARAMETER (VERTICAL SUBGRADE STRAIN)

1) Traffic = 3,05,000
   CBR = 3.5%
   Design life = 10 years
2) Traffic = 6,68,980
   CBR = 11.6%
   Design life = 17 years

Later, life cycle cost of these two alternatives are calculated and compared.

3.7.1 Alternative 1

3.7.1.1: Item wise Initial Cost calculation

Table 3.5 Analysis of Rates considered for Embankment (Source: Department of Works – Government of Odisha, 2014)

Sl. No.		Description	Unit	Quantity	Rate Rs. P	Cost Rs. P
1		2	3	4	5	6
		Construction of embankment with approved material obtained from borrow pits with all lifts and leads, transporting to site by mechanical means within a lead of 5kms, spreading, grading to required slope and compacting to meet requirement of table 300-2 & Clause 305 of MoSRT&H Specifications for Road & Bridge works (4th Revision) **Unit = cum** **Taking output = 100 cum**				
	a)	**Labour**				
		Mate	each	0.040	170.00	6.80
		Mulia unskilled	each	1.000	190.00	190.00
						196.80
	b)	**Machinery**				
		Hydraulic Excavator1 cum bucket capacity @ 60 cum per hour	hour	1.670	840.00	1402.80
		Tipper 10 tonne capacity	tonne.km	800.000	2.50	2000.00
		Add 10 per cent of cost of carriage to cover cost of loading and unloading				200.00
		Dozer 80 HP for spreading @ 200 cum per hour	hour	0.500	2519.00	1259.50
		Motor grader for grading @ 100 cum per hour	hour	1.000	1545.00	1545.00
		Water tanker 6 KL capacity	hour	4.000	582.00	2328.00
		Vibratory roller 8 -10 tonnes @ 100 cum per hour	hour	1.000	994.00	994.00
						9729.30
	c)	**Material**				
		Compensation for earth taken from private land	cum	100.000	0.00	0.00
		Cost of water	KL	24.000	15.00	360.00
						360.00
	d)	**Overhead Charges @ 10 % on (a+b+c)**				**1028.61**
		Cost for 100 sqm = a+b+c+d				**11314.71**
		Rate per sqm = (a+b+c+d)/100				**113.15**
					Say	**113.10**

Table 3.6 Analysis of Rates considered for Sub grade (Source: Department of Works – Government of Odisha, 2014)

Sl. No.	Description			Unit	Quantity	Rate Rs. P	Cost Rs. P
1	2			3	4	5	6
	Rolling and compacting to sub grade or formation loosening by cutting ordinary earth for 0.15 Mtr. depth including watering and rolling by PRR as per specification and direction of Engineer-in Charge **Unit = cum** **Taking output = 100 cum**						
	a)						
		i)	Labour				
			Male Mulia	each	25.000	150.00	3750.00
			Female Mulia	each	25.000	150.00	3750.00
		ii)	Overhead Charges @ 10 % on i)				750.00
		iii)	2% Sundries and T & P etc. on (i)				150.00
							8400.00
						per cum	**84.00**
	b)		**Machinery**				
			1. Hire and running charges of P.R.R. Rs. 802.00/hr (considering a roller will compact 25 cum/hour)				
			For 100 cum	Rs 802 * 8			6416.00
			2. Cost of watering with an av. Lead of 5km by truck (considering carrying water 20Nos. Of maxphalt drums in each trip) 5 trips of water required for 390 cum of earth				
			For 100 cum of earth	trip	1.28	582	744.96
			3. Labour charges for sprinkling water, labour required for 390 cum 50 Nos.				
			For 100 cum of earth				
			Man mulia	each	12.80	150	1920.00
			Overhead Charges = 10%				908.10
			Total				9989.06
						per cum	**99.89**
			Rate per cum = (a+b)				183.89
						Say	**183.90**

Table 3.7 Analysis of Rates considered for Shoulder (Source: Department of Works – Government of Odisha, 2014)

Sl. No.	Description			Unit	Quantity	Rate Rs. P	Cost Rs. P
1	2			3	4	5	6
	Rolling and compacting to shoulder or formation loosening by cutting ordinary earth for 0.15 Mtr. depth including watering and rolling by PRR as per specification and direction of Engineer-in Charge **Unit = cum** **Taking output = 100 cum**						
	a)	i)	Labour				
			Male Mulia	each	25.000	150.00	3750.00
			Female mulia	each	25.000	150.00	3750.00
		ii)	Overhead Charges @ 10 % on i)				750.00
		iii)	2% Sundries and T & P etc. on (i)				150.00
							8400.00
						per cum	**84.00**
	b)		**Machinery**				
			1. Hire and running charges of P.R.R. Rs. 802.00/hr (considering a roller will compact 25 cum/hour)				
			For 100 cum		Rs 802 * 8		6416.00
			2. Cost of watering with an av. Lead of 5km by truck (considering carrying water 20Nos. Of maxphalt drums in each trip) 5 trips of water required for 390 cum of earth				
			For 100 cum of earth	trip	1.28	582	744.96
			3. Labour charges for sprinkling water, labour required for 390 cum 50 Nos.				
			For 100 cum of earth				
			Man mulia	each	12.80	150	1920.00
			Overhead Charges = 10%				908.10
			Total				9989.06
						per cum	**99.89**
			Rate per cum = (a+b)				183.89
						Say	**183.90**

Table 3.8 Analysis of Rates considered for GSB (Source: Department of Works – Government of Odisha, 2014)

Sl. No.		Description	Unit	Quantity	Rate	Cost
					Rs. P	Rs. P
1		2	3	4	5	6
		Construction of granular sub-base by providing Close graded Granular sub base Grading-III material as per table 400-1, spreading in uniform layers with motor grader on prepared surface, mixing by mix in place method with rotavator at OMC, and compacting with vibratory roller to achieve the desired density complete as per Clause 401 of MoSRT&H Specifications for Road & Bridge works (4th Revision)				
		Unit = cum				
		Taking output = 300 cum				
	a)	**Labour**				
		Mate	each	0.480	170.00	81.60
		Mulia skilled	each	2.000	190.00	380.00
		Mulia unskilled	each	10.000	150.00	1500.00
						1961.60
	b)	**Machinery**				
		Motor Grader 110 HP @ 50 cum per hour	hour	6.000	1545.00	9270.00
		Vibratory roller 8 -10 tonne capacity	hour	6.000	994.00	5964.00
		Tractor - Rotavator	hour	12.000	289.00	3468.00
		Water tanker 6 KL capacity	hour	3.000	582.00	1746.00
						20448.00
	c)	**Material**				
		9.5 mm to 4.75 mm @ 35 per cent	cum	67.200	913.00	61353.60
		4.75 mm to 2.36 mm @ 12.5 per cent	cum	24.000	698.00	16752.00
		2.36 mm below @ 52.5 per cent	cum	100.800	611.00	61588.80
		Cost of water	KL	18.000	10.00	180.00
						139874.40
	d)	**Overhead charges @10% on (a+b+c)**				**16228.40**
		Cost for 300 cum = a+b+c+d				178512.40
		Rate per cum = (a+b+c+d)/300				**595.04**
					Say	**595.10**

Table 3.9 Analysis of Rates considered for WBM Grade-I (Source: Department of Works – Government of Odisha, 2014)

Sl. No.			Description	Unit	Quantity	Rate Rs. P	Cost Rs. P
1			2	3	4	5	6
			Providing, laying, spreading and compacting stone aggregates of specific sizes to water bound macadam specification including spreading in uniform thickness, hand packing, rolling with 3 wheeled steel roller 8-10 tonnes in stages to proper grade and camber, applying and brooming requisite type of screening/binding materials to fill up the interstices of coarse aggregate, watering and compacting to the required density as per Clause 404 of MoSRT&H Specifications for Road & Bridge works (4th Revision) **Unit = cum** **Taking output = 200 cum**				
	a)		**Labour**				
			Mate	each	10.080	170.00	1713.60
			Mulia skilled	each	2.000	190.00	380.00
			Mulia unskilled	each	250.000	150.00	37500.00
							39593.60
	b)		**Machinery**				
			Smooth 3 wheeled steel roller @ 30cum/hour	hour	12.000	339.00	4068.00
			Water tanker 6 KL capacity	hour	24.000	582.00	13968.00
							18036.00
	c)		**Material [Grading-I]**				
		A)	**Using moorum or gravel**				
			Grading-I 90 mm to 45 mm @ 1.21cum per 10 sqm for compacted thickness of 100 mm	cum	435.600	602.00	262231.20
			Crushable type such as Moorum or Gravel for grading-I @ 0.30 cum per 10 sqm	cum	108.000	47.00	5076.00
			Cost of water	KL	144.000	15.00	2160.00
		B)	**Using stone screened dust**				
			Stone screened dust for grading-I @ 0.27 cum per 10 sqm	cum	97.200	84.00	8164.80
			Binding Material @ 0.08cum per 10 sqm for grading I material	cum	28.800	84.00	2419.20
			Cost of Water	KL	144.000	15.00	2160.00
							282211.20
	d)		**Overhead charges @10% on (a+b+c)**				**33984.08**
			Cost for 200 cum = a+b+c+d				373824.88
			Rate per cum = (a+b+c+d)/200				**1869.12**
						Say	**1869.20**

Table 3.10 Analysis of Rates considered for WBM Grade-II (Source: Department of Works – Government of Odisha, 2014)

Sl. No.	Description			Unit	Quantity	Rate Rs. P	Cost Rs. P
1	2			3	4	5	6
	Providing, laying, spreading and compacting stone aggregates of specific sizes to water bound macadam specification including spreading in uniform thickness, hand packing, rolling with 3 wheeled steel roller 8-10 tonnes in stages to proper grade and camber, applying and brooming requisite type of screening/binding materials to fill up the interstices of coarse aggregate, watering and compacting to the required density as per Clause 404 of MoSRT&H Specifications for Road & Bridge works (4th Revision) **Unit = cum** **Taking output = 200 cum**						
	a)	**Labour**					
			Mate	each	10.080	170.00	1713.60
			Mulia skilled	each	2.000	190.00	380.00
			Mulia unskilled	each	250.000	150.00	37500.00
							39593.60
	b)	**Machinery**					
			Smooth 3 wheeled steel roller @ 30cum/hour	hour	12.000	339.00	4068.00
			Water tanker 6 KL capacity	hour	24.000	582.00	13968.00
							18036.00
	c)	**Material [Grading-II]**					
		A)	**Using moorum or gravel**				
			Grading-II 63 mm to 45 mm @ 0.91 cum per 10 sqm for compacted thickness of 75 mm	cum	435.600	668.00	290980.80
			Crushable type such as Moorum or Gravel for grading-II @ 0.22 cum per 10 sqm	cum	105.590	47.00	4962.73
			Cost of water	KL	144.000	15.00	2160.00
		B)	**Using stone screened dust**				
			Stone screened dust for grading-II @ 0.18 cum per 10 sqm	cum	96.010	84.00	8064.84
			Binding Material @ 0.06cum per 10 sqm for grading II material	cum	28.800	84.00	2419.20
			Cost of Water	KL	144.000	15.00	2160.00
							310747.57
	d)		**Overhead charges @10% on (a+b+c)**				**36837.72**
			Cost for 200 cum = a+b+c+d				405214.89
			Rate per cum = (a+b+c+d)/200				**2026.07**
						Say	**2026.10**

Table 3.11 Analysis of Rates considered for WBM Grade-III (Source: Department of Works – Government of Odisha, 2014)

Sl. No.	Description	Unit	Quantity	Rate Rs. P	Cost Rs. P
1	2	3	4	5	6
	Providing, laying, spreading and compacting stone aggregates of specific sizes to water bound macadam specification including spreading in uniform thickness, hand packing, rolling with 3 wheeled steel roller 8-10 tonnes in stages to proper grade and camber, applying and brooming requisite type of screening/binding materials to fill up the interstices of coarse aggregate, watering and compacting to the required density as per Clause 404 of MoSRT&H Specifications for Road & Bridge works (4th Revision)				
	Unit = cum				
	Taking output = 200 cum				
	a) Labour				
	Mate	each	10.080	170.00	1713.60
	Mulia skilled	each	2.000	190.00	380.00
	Mulia unskilled	each	250.000	150.00	37500.00
					39593.60
	b) Machinery				
	Smooth 3 wheeled steel roller @ 30cum/hour	hour	12.000	339.00	4068.00
	Water tanker 6 KL capacity	hour	24.000	582.00	13968.00
					18036.00
	c) Material [Grading-II]				
	A) Using moorum or gravel				
	Grading-III 53 mm to 22.4 mm @ 0.91 cum per 10 sqm for compacted thickness of 75 mm	cum	435.600	713.00	310582.80
	Crushable type such as Moorum or Gravel for grading-III @ 0.22 cum per 10 sqm	cum	105.590	47.00	4962.73
	Cost of water	KL	144.000	15.00	2160.00
	B) Using stone screened dust				
	Binding Material @ 0.06cum per 10 sqm for grading III material	cum	28.800	84.00	2419.20
	Cost of Water	KL	144.000	15.00	2160.00
					329542.33
	d) Overhead charges @10% on (a+b+c)				**38717.19**
	Cost for 200 cum = a+b+c+d				425889.12
	Rate per cum = (a+b+c+d)/200				**2129.45**
				Say	**2129.50**

Table 3.12 Analysis of Rates considered for Primer Coat (Source: Department of Works – Government of Odisha, 2014)

Sl. No.	Description		Unit	Quantity	Rate Rs. P	Cost Rs. P
1	2		3	4	5	6
	Providing and applying primer coat with bitumen emulsion on prepared surface of granular Base including clearing of road surface and spraying primer at the rate of 0.60 kg/sqm using mechanical means as per Clause 502 of MoSRT&H Specifications for Road & Bridge works (4th Revision). **Unit = sqm** **Taking output = 1750 sqm**					
	a)	**Labour**				
		Mate	each	0.080	170.00	13.60
		Mulia unskilled	each	2.000	150.00	300.00
						313.60
	b)	**Machinery**				
		Mechanical broom @ 1250 sqm per hour	hour	2.800	230.00	644.00
		Air compressor 250 cfm	hour	2.800	206.00	576.80
		Emulsion pressure distributor @ 1750 sqm per hour	hour	2.000	516.00	1032.00
		Water tanker 6 KL capacity @ 1 trip per hour	hour	1.000	582.00	582.00
						2834.80
	c)	**Material**				
		Slow setting Bitumen emulsion @ 0.6 kg per sqm	tonne	2.100	27715.40	58202.34
		Cost of water	KL	6.000	15.00	90.00
						58292.34
	d)	**Overhead Charges @ 10 % on (a+b+c)**				**6144.07**
		Cost for 1750 sqm = a+b+c+d				**67584.81**
		Rate per sqm = (a+b+c+d)/1750				**38.62**
					Say	**38.60**
Bitumen primer has been provided @ 0.60 kg per sqm as per clause 502.8. Payment shall be made with adjustment, plus or minus, for the variation between this quantity and the actual quantity approved by the Engineer after the preliminary trials referred to Clause No.502,4,3						

Table 3.13 Analysis of Rates considered for Tack Coat (Source: Department of Works – Government of Odisha, 2014)

<table>
<tr><th rowspan="2">Sl. No.</th><th colspan="2" rowspan="2">Description</th><th rowspan="2">Unit</th><th rowspan="2">Quantity</th><th>Rate</th><th>Cost</th></tr>
<tr><th>Rs. P</th><th>Rs. P</th></tr>
<tr><td>1</td><td colspan="2">2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td></td><td colspan="2">Providing and applying tack coat with bitumen emulsion using emulsion pressure distributor at the rate of 0.20 kg per sqm on the prepared bituminous/granular surface cleaned with mechanical broom as per Clause 503 of MoSRT&H Specifications for Road & Bridge works (4th Revision)
Unit = sqm
Taking output = 1750 sqm</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>a)</td><td>Labour
Mate
Mulia unskilled</td><td>
each
each</td><td>
0.080
2.000</td><td>
170.00
150.00</td><td>
13.60
300.00</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>313.60</td></tr>
<tr><td></td><td>b)</td><td>Machinery
Mechanical broom @ 1250 sqm per hour
Air compressor 250 cfm
Emulsion pressure distributor @ 1750 sqm per hour</td><td>
hour
hour
hour</td><td>
2.800
2.800
2.000</td><td>
230.00
206.00
516.00</td><td>
644.00
576.80
1032.00</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>2252.80</td></tr>
<tr><td></td><td>c)</td><td>Material
Rapid setting Bitumen emulsion @ 0.2 kg per sqm</td><td>
tonne</td><td>
0.900</td><td>
28145.40</td><td>
25330.86</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>25330.86</td></tr>
<tr><td></td><td>d)</td><td>Overhead Charges @ 10 % on (a+b+c)
Cost for 1750 sqm = a+b+c+d
Rate per sqm = (a+b+c+d)/1750</td><td></td><td></td><td></td><td>2789.73
30686.99
17.54</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>Say</td><td>17.50</td></tr>
<tr><td colspan="7">Note
1. Bitumen primer has been provided @ 0.60 kg per sqm as per clause 502.8. Payment shall be made with adjustment, plus or minus, for the variation between this quantity and the actual quantity approved by the Engineer after the preliminary trials referred to Clause No.502,4,3
2. An output of 1750 sqm has been considered in case of prime coat and tack coat which can be covered by bituminous courses on the same day.</td></tr>
</table>

Table 3.14 Analysis of Rates considered for PC (Source: Department of Works – Government of Odisha, 2014)

Sl. No.		Description	Unit	Quantity	Rate Rs. P	Cost Rs. P
1		2	3	4	5	6
		Providing, laying and rolling of open - graded premix surfacing of 20 mm thickness composed of 13.2 mm to 5.6 mm aggregates with batch type hot mix plant and using VG 30 bitumen to required line, grade and level to serve as wearing course on a previously prepared base including mixing in a suitable plant, laying and rolling with a smooth wheeled roller 8-10 tonne capacity, finished to required level and grades as per Clause 511 of MoSRT&H Specifications for Road & Bridge works (4th Revision) **Unit = sqm** **Taking output = 5250 sqm**				
	a)	**Labour**				
		Mate	each	0.760	170.00	129.20
		Mulia unskilled working with HMP, road sweeper, paver and roller	each	14.000	150.00	2100.00
		Mulia Skilled for checking line	each	5.000	190.00	950.00
						3179.20
	b)	**Machinery**				
		Batch type HMP 100-120 TPH @ 75 tonne per hour	hour	6.000	11167.00	67002.00
		Electric Generator Set 250 KVA	hour	6.000	1125.00	6750.00
		Front end loader 1 cum bucket capacity	hour	6.000	520.00	3120.00
		Tipper 10 tonne capacity	tonne.km	450.000	2.50	1125.00
		Add 10 per cent of cost of carriage to cover cost of loading and unloading				112.50
		Paver finisher Mechanical 100TPH	hour	6.000	1846.00	11076.00
		Smooth wheeled roller 8-10 tonnes weight	hour	6.000	339.00	2034.00
						91219.50
	c)	**Material**				
		VG 30	tonne	14.965	29970.00	448501.05
		13.2mm nominal size @ 0.18 cum per 10 sqm	cum	184.500	1088.00	200736.00
		11.2mm nominal size @ 0.09 cum per 10 sqm	cum	92.250	1133.00	104519.25
						753756.30
	d)	**Overhead Charges @ 10 % on (a+b+c)**				**84815.50**
		Cost for 5250 sqm = a+b+c+d				**932970.50**
		Rate per sqm = (a+b+c+d)/5250				**177.71**
Note					**Say**	**177.80**

Premix sand seal coat of 'B' type is proposed to be provided over the open graded premix carpet immediately on the same day. As the same HMP and other machines will be used for laying of premix sand seal coat, out of 6 effective working hours, 4.00 hours may be utilised for laying of premix carpet and balance 2.00 hours for the purpose of seal coat. In case type-A seal coat is proposed, HMP can be worked out for six hours for the premix carpet as type-A seal coat does not require the use of HMP.

Table 3.15 Analysis of Rates considered for Seal Coat (Source: Department of Works – Government of Odisha, 2014)

Sl. No.			Description	Unit	Quantity	Rate Rs. P	Cost Rs. P
1			2	3	4	5	6
	Providing and laying seal coat sealing the voids in a bituminous surface laid to the specified levels, grade and cross fall using Type-A seal coat with 0.09cum of 6.7mm size chips and 9.80kg. of VG 30 bitumen for 10sqm as per Clause No. 513 of MoSRT&H specifications for Road & Bridge works (4th Revision) **Unit = sqm** **Taking output = 5250 sqm**						
	a)		**Labour**				
			Mate	each	0.240	170.00	40.80
			Mulia unskilled	each	6.000	150.00	900.00
							940.80
	b)		**Machinery**				
			Hydraulic self-propelled chip spreader	hour	6.000	1700.00	10200.00
			Tipper 5.5 cum capacity	hour	6.000	506.00	3036.00
			Front end loader 1 cum bucket capacity	hour	6.000	520.00	3120.00
			Bitumen pressure distributor @ 1750 sqm per hour	hour	6.000	692.00	4152.00
			Smooth wheeled roller 8 -10 tonne weight	hour	6.000	339.00	2034.00
							22542.00
	c)		**Material**				
			VG 30	tonne	10.045	29970.00	301048.65
			Crushed stone chipping of 6.7 mm size defined as 100 per cent passing 11.2 mm sieve and retained on 2.36 mm sieve applied @ 0.09 cum per 10	cum	92.250	765.00	70571.25
							371619.90
	d)		**Overhead Charges @ 10 % on (a+b+c)**				**39510.27**
			Cost for 5250 sqm = a+b+c+d				**434612.97**
			Rate per sqm = (a+b+c+d)/5250				**82.78**
						Say	**82.80**

3.6.1.2 Total Initial Cost

Table 3.16: Total Initial Cost for Alternative 1

Composition	Thickness (mm)	Length (m)	Rate	Unit of rate	Cost, Rs./m
Embankment	1000	7	113.1	per cum	791.70
Sub grade	300	6	183.9	per cum	331.02
Shoulder	1800	3	183.9	per cum	993.06
GSB	225	4	595.2	per cum	535.68
WBM-grade I	100	3	1869.2	per cum	560.76
WBM-grade II	75	3	2026.1	per cum	455.87
WBM-grade III	75	3	2129.5	per cum	479.14
Prime coat	NA	3	38.6	per sqm	115.80
Tack coat	NA	3	17.5	per sqm	52.50
Premix carpet (20 mm)	NA	3	177.8	per sqm	533.40
Seal coat	NA	3	82.8	per sqm	248.40
					5097.33
				Lakh Rupees per km	**50.97**

3.6.1.3 Maintenance Cost of Flexible Pavement

i) It will be assumed that one layer of WBM grade III will be laid on the 10th year after construction of road with 75mm WBM.

ii) Surface renewals are to be provided once in 5 years of 20mm PC.

iii) The cost of routine maintenance per year for this road with flexible pavement has been assumed that 5-8% of initial cost over 5 years.

3.6.1.4 Cost Estimate

i) Initial Cost of Flexible Pavement = Rs. 50.97 lakhs per km

ii) Annual Maintenance of Flexible Pavement over 5 years = Rs. 4.08 lakhs per km

iii) Renewal of premix carpet + seal coat of flexible pavement every 5 years = 7.82 lakhs

iv) Strengthening with WBM grade III every 10^{th} year, 75mm = 14.30 lakhs

3.6.1.5 Life Cycle Cost Analysis

(EXAMPLE OF BITUMINOUS ROADS IN RURAL AREAS UNDER PMGSY)

DATA:

- Analysis Period = 10 Years
- Discount Rate = 4%
- Inflation Rate = 4% Per Year
- Flexible (BT) Construction Cost = 50.97 Rs Lakhs Per km
- Routine Maintenance/ 5Years = 4.08 Rs Lakhs Per km
- Renewal (5 Years) = 7.82 Rs Lakhs Per km
- Strengthen (10 Years) = 14.30 Rs Lakhs Per km

Table 3.17: Total Construction Cost for Alternative 1

Year	Construction Cost	Maintenance Cost	NPV$(1/1.04)^n$
0	50.97	-	50.97
1	-	0.64	0.4324
2	-	0.69	0.4661
3	-	0.76	0.5134
4	-	0.89	0.6013
5	-	8.91	6.0193
6	-	0.66	0.4459
7	-	0.69	0.4661
8	-	0.79	0.5337
9	-	0.92	0.6215
10	-	15.31	10.3429
Total NPV			**71.41**

3.6.2 Alternative 2

3.6.2.1 Calculation of fly ash:

- γd = 1.34 gm /cc
- Volume of sub grade = 100 cum = 10^8 cc
- Mass = $1.34*10^8$ = 134000 kg

46% fly ash is used: means that means if X is the amount of soil used in subgrade then 0.46X is the amount of fly ash used in the soil for stabilization. Then,

- X+0.46X = 134000 kg
- X = 91780.822 kg
- Amount of fly ash = 42220 kg = 42.33 tonne

3.6.2.2 Initial Cost Calculation

Table 3.18 Analysis of Rates considered for Sub grade using Fly Ash (Source: Department of Works – Government of Odisha, 2014)

Sl. No.			Description	Unit	Quantity	Rate Rs. P	Cost Rs. P
1			2	3	4	5	6
			Rolling and compacting to sub grade or formation loosening by cutting ordinary earth for 0.15 Mtr. depth including watering and rolling by PRR and adding fly ash for soil stabilisation as per specification and direction of Engineer-in Charge and journal. **Unit = cum** **Taking output = 100 cum**				
	a)	i)	Labour				
			Male Mulia	each	25.000	150.00	3750.00
			Female mulia	each	25.000	150.00	3750.00
		ii)	Overhead Charges @ 10 % on i)				750.00
		iii)	2% Sundries and T & P etc. on (i)				150.00
							8400.00
						per cum	**84.00**
	b)		**Machinery**				
			1. Hire and running charges of P.R.R. Rs. 269.00/hr (considering a roller will compact 425 cum/day)				
			For 100 cum	Rs 802 * 8			6416.00
			2. Cost of watering with an av. Lead of 5km by truck (considering carrying water 20Nos. Of max phalt drums in each trip) 5 trips of water required for 390 cum of earth				
			For 100 cum of earth	trip	1.28	582	744.96
			3. Labour charges for sprinkling water, labour required for 390 cum 50 Nos. For 100 cum of earth				
			Man Mulia	each	8.80	150	1320.00
			Overhead Charges = 10%				848.10
			Total				9329.06
						per cum	**93.29**
	c)		**Material**				
			Fly Ash	tonne	42.220	1500.00	63330.00
			Overhead Charges = 10%				6333.00
							69663.00
						per cum	**696.63**
			Rate per cum = (a+b+c)				873.92
						Say	**874.00**

3.6.2.3 Total Initial Cost

Initial cost calculation of pavement layers other than sub grade is done according to the procedure adopted in case of Alternative 1.

Table 3.19: Total Initial Cost for Alternative 2

Composition	Thickness (mm)	Length (m)	Rate	Unit of rate	Cost Rs./m
WBM-grade III	75	3	2129.5	per cum	479.14
WBM-grade II	75	3	2026.1	per cum	455.87
WBM-grade I	100	3	1869.2	per cum	560.76
GSB	100	4	595.2	per cum	238.08
Sub grade	300	6	874	per cum	1573.20
Embankment	1000	7	113.1	per cum	791.70
Shoulder	1800	3	183.9	per cum	993.06
Prime coat	NA	3	38.6	per sqm	115.80
Tack coat	NA	3	17.5	per sqm	52.50
Premix carpet 20 mm	NA	3	177.8	per sqm	533.40
Seal coat	NA	3	82.8	per sqm	248.40
					6041.91
				Lakh Rupees per km	**60.42**

3.6.2.4 Maintenance Cost of Flexible Pavement

i) It will be assumed that one layer of WBM grade III will be laid on 10th years after construction of road with 75mm WBM.

ii) Surface renewals are to be provided once in 5 years of 20mm PC with seal coat.

iii) The cost of routine maintenance for this road with flexible pavement has been assumed 5-8% of initial construction cost over a period of 5 years.

3.6.2.5 Cost Estimate

i) Initial Cost of Flexible Pavement = Rs. 60.42 lakhs per km

ii) Annual Maintenance of Flexible Pavement over 5 years= Rs. 4.83 lakhs per km

iii) Renewal of premix carpet + seal coat of flexible pavement every 5 years = 7.82 lakhs

iv) Strengthening with WBM grade III every 10^{th} year, 75mm = 14.30 lakhs

3.6.2.6 Life Cycle Cost Analysis

(BITUMINOUS ROADS IN RURAL AREAS UNDER PMGSY)

DATA:

- Analysis Period = 17 Years
- Discount Rate = 4%
- Inflation Rate = 4% Per Year
- Flexible (BT) Initial Construction Cost = Rs. 60.42 Lakhs Per km
- Routine Maintenance/ 5 Years = Rs. 4.83 Lakhs Per km
- Renewal (5 Years) = Rs. 7.82 Lakhs Per km
- Strengthen (10 Years) = Rs. 14.30 Lakhs Per km

Table 3.20: Total Construction Cost for Alternative 2.

Year	Construction Cost	Maintenance Cost	NPV$(1/1.04)^n$
0	60.42	-	60.42
1	-	0.76	0.5134
2	-	0.82	0.5540
3	-	0.91	0.6148
4	-	1.06	0.7161
5	-	9.12	6.1611
6	-	0.79	0.5337
7	-	0.82	0.5540
8	-	0.94	0.6350
9	-	1.09	0.7364
10	-	15.5	10.4712
11	-	0.73	0.4932
12	-	0.85	0.5742
13	-	0.88	0.5945
14	-	1.09	0.7364
15	-	9.13	6.1679
16	-	0.79	0.5337
17	-	0.94	0.6350
Total NPV			**91.64**

CHAPTER 4

4.1 RESULT AND DISCUSSION

4.1.1 1st case

- Total cost for 10 years design life period = Rs. 71.41 lakhs
- LCCA = 71.41 lakhs/10 = Rs. 7.14 lakhs/year/km

4.1.2 2nd case

- Total cost for 17 years design life period = Rs. 91.64 lakhs
- LCCA = 91.64 lakhs/17 = Rs. 5.39 lakhs/year/km

4.1.3 Comparison between both cases

LCCA differences between alternatives = ((7.14-5.39)/5.39) x 100

= 32.47 % > **20 %**

Life cycle cost analysis has been conducted for two alternatives: alternative 1 which is for normal soil without stabilisation and alternative 2 which is after stabilisation of sub grade soil using fly ash. It is evident from above result that the LCCA differences between these two alternatives > 20% which shows alternative 2 is more cost beneficial than alternative 1 because of its low construction cost/year/km.

CHAPTER 5

SUMMARY

In this study an attempt has been made to determine the most favourable alternative for any general bituminous pavement of low volume roads at average weather conditions.

i) By KENPAVE software analysis it was concluded that for the same considered critical parameter which is vertical strain at subgrade, traffic intensity increases for the stabilised soil than the normal soil.

ii) This study also shows that beneficial uses of stabilisation of subgrade soil with fly ash, in that the CBR value is increased and the total construction cost of the same project is decreased in terms of economical and serviceability.

iii) Finally an economic comparison is carried out between these two alternatives to find out the cost-beneficial pavement design for the low volume roads. It is observed that the stabilisation option leads to about 33% savings interms of the life cycle cost.

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